JC03 Rec'd PCT/PTO 17 JAN 2002

FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **10191/2231**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/031526

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED:
PCT/DE00/02061	**24 June 2000 (24.06.00)**	**20 July 1999 (20.07.99)**

TITLE OF INVENTION
BIDIRECTIONAL SEMICONDUCTOR COMPONENT

APPLICANT(S) FOR DO/EO/US
Robert PLIKAT and Wolfgang FEILER

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U S C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S C 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U S C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau)
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U S C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau)
   b. ☐ have. been transmitted by the International Bureau
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned)
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5))

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment
14. ☒ A substitute specification and marked-up version thereof.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information. International Search Report (translated), Preliminary Examination Report and PCT/RO/101.

EXPRESS MAIL NO.: EL244510475

U.S. APPLICATION NO. if known, see 37 C.F.R.1.5 10/031526	INTERNATIONAL APPLICATION NO PCT/DE00/02061	ATTORNEY'S DOCKET NUMBER 10191/2231

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17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO $890.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $710.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $740.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,040.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 890	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	8 - 20 =	0	X $18.00	$ 0	
Independent Claims	2 - 3 =	0	X $84.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 890	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 890	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 890	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 890	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$890.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: [signature] (Reg. No. 41,172)

Richard L. Mayer

SIGNATURE

SEND ALL CORRESPONDENCE TO:
Kenyon & Kenyon
One Broadway
New York, New York 10004

Customer No. 26646

Richard L. Mayer, Reg. No. 22,490

NAME

1/17/02

DATE

10/031526

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[10191/2231]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors	:	PLIKAT et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	BIDIRECTIONAL SEMICONDUCTOR COMPONENT
Examiner	:	To Be Assigned
Art Unit	:	To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231
Box Patent Application

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to: --What Is Claimed Is:--.

Please cancel original claims 1 to 8, without prejudice in the underlying PCT Application No. PCT/DE00/02061.

EL244510475

Please add the following new claims:

9. (New) A bidirectional semiconductor component, comprising:

a substrate including a drain region; and

two symmetrical MOS transistor structures integrated laterally in the substrate and connected to each other antiserially, a drain terminal of each of the two symmetrical MOS transistor structures being connected to one another, wherein:

a zone having a conductivity that is the same as a conductivity of the drain region and having a doping that is higher than a doping of the drain region is situated upstream from a pn junction of one of the two symmetrical MOS transistor structures in a junction area with the drain region.

10. (New) The bidirectional semiconductor component according to claim 9, wherein:

the drain region and the zone are n-doped.

11. (New) The bidirectional semiconductor component according to claim 9, further comprising:

a layer on which the drain region is situated and having a doping that is opposite that of the conductivity of the drain region.

12. (New) The bidirectional semiconductor component according to claim 11,wherein:

the layer includes a plurality of partial layers having stepped doping.

13. (New) A method of using a bidirectional semiconductor component, comprising the step of:

using the bidirectional semiconductor component as a short-circuit switch to short circuit a primary winding of an ignition coil in an ignition power module of an ignition system of an internal combustion engine, wherein the bidirectional semiconductor component includes:

a substrate including a drain region; and

two symmetrical MOS transistor structures integrated laterally in the substrate and connected to each other antiserially, a drain terminal of each of the two symmetrical MOS transistor structures being connected to one another wherein:

a zone having a conductivity that is the same as a conductivity of the drain region and having a doping that is higher than a doping of the drain region is situated upstream from a pn junction of one of the two symmetrical MOS transistor structures in a junction area with the drain region.

14. (New) The method according to claim 13, further comprising the steps of:

performing a time-staggered activation of gate terminals of the two symmetrical MOS transistor structures in a time-staggered manner; and

activating at a later time one of the two symmetrical MOS transistor structures that blocks a higher voltage.

15. (New) The ignition system according to claim 14, wherein:

the time-staggered activation is performed by interconnecting a capacitor.

16. (New) The ignition system according to claim 14, wherein:

the time-staggered activation is performed by a time control.

Remarks

This Preliminary Amendment cancels original claims 1-8, without prejudice in the underlying PCT Application No. PCT/DE00/02061. The Preliminary Amendment also adds new claims 9-16. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the

Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE00/02061 includes an International Search Report, dated November 3, 2000, and an International Preliminary Examination Report, dated July 16, 2001, copies of which are submitted herewith.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: [illegible] (Reg. No. 41,172)

Dated: 1/17/02

By: Richard L. Mayer

Richard L. Mayer
(Reg. No. 22,490)

One Broadway
New York, NY 10004
(212) 425-7200

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[10191/2231]

BIDIRECTIONAL SEMICONDUCTOR COMPONENT

Field Of The Invention

The present invention relates to a bidirectional semiconductor component having two symmetrical MOS transistor structures in an antiserial configuration, integrated laterally into a substrate, their drain terminals interconnected.

Background Information

Bidirectional semiconductor components of the generic type are described in S. Xu et al. in "Bidirectional LIGBT on SOI substrate with high frequency and high temperature capability" IEEE, 2/97. Due to the completely symmetrical design described there in combination with the antiserial configuration of the MOS transistors, the known bidirectional semiconductor component is suitable for use as a matrix switch in telecommunications systems or the like. Asymmetrical applications, such as those in automotive ignition system control circuits, cannot be implemented by the known bidirectional semiconductor components because the required blocking ability of approx. 400 V can be achieved only asymmetrically at the present time.

Summary Of The Invention

The bidirectional semiconductor component according to the present invention offers the advantage over the related art that it is possible to implement blocking voltages of different levels. An asymmetrical blocking ability may be achieved with a simultaneous guarantee of a low resistance at powerup due to the fact that a zone having the same type of conductivity as the drain region, however, having a higher doping than the drain region, is located upstream from a pn junction of one of the MOS transistors in a junction area with the drain region.

Due to the advantages achievable with the design of the bidirectional semiconductor

component according to the present invention, it is especially suitable for use as a short-circuit switch for short circuiting a primary winding of an ignition coil in an ignition system of a motor vehicle. It is known that with an ionic current ignition, the primary winding of the ignition coil is to be short-circuited by the secondary winding of the ignition coil after the ignition pulse has been triggered on a sparkplug because extinction of the spark is defined by this short-circuiting. In this use as provided according to the present invention, the bidirectional semiconductor component used as a short-circuit switch receives blocking voltages of different levels, namely the battery voltage on the one hand and the terminal voltage of a transistor stage connected as a Darlington, for example, on the other hand. According to the buffering of the pn junction of the one MOS transistor provided with the bidirectional semiconductor component according to the present invention, it is possible to achieve an asymmetrical blocking ability of the semiconductor component by way of which the different blocking voltages can be compensated for.

Brief Description Of The Drawings

Figure 1 shows a schematic view of a bidirectional semiconductor component according to the present invention.

Figure 2 shows a circuit arrangement of an ignition power module using the bidirectional semiconductor component according to the present invention.

Figure 3 shows a preferred embodiment of the bidirectional semiconductor component according to the present invention.

Figures 4 and 5 show schematic process steps for manufacturing the bidirectional semiconductor component according to the present invention.

Detailed Description

Figure 1 shows a schematic block diagram of a bidirectional semiconductor component 10. Bidirectional semiconductor component 10 includes a substrate 12 having a first charge carrier doping (e.g., n-type doping). Charge carrier regions 14 and 14' having a charge carrier

doping (e.g., p-type doping) opposite the first charge carrier doping are integrated into substrate 12. Charge carrier regions 14 and 14' are symmetrical. Charge carrier regions 16 and 16' having the same charge carrier doping as substrate 12 (e.g., n-type doping) are integrated into charge carrier regions 14 and 14'. Charge carrier regions 14 and 16 are electrically connected to a common metallic coating (electrode) 18 and charge carrier regions 14' and 16' are electrically connected to a common metallic coating (electrode) 18'. Furthermore, charge carrier region 14 is provided with another insulated electrode (poly-Si gate) 20, and charge carrier region 14' is provided with another insulated electrode (poly-Si gate) 20'.

pn junctions 22 or 22' and 24 or 24' are formed due to the arrangement of charge carrier regions 12, 14, 16, and 12, 14', 16'.

Substrate 12 of the first type of conductivity is weakly doped, while charge carrier region 16 or 16' of the same type of conductivity is highly doped. Charge carrier regions 14 or 14' of the other type of conductivity is moderately doped. An antiserial configuration of two MOS transistors 26 or 26' is formed due to such an essentially known structure of semiconductor component 10.

In addition, a charge carrier region 28 extending into substrate 12 is provided for pn junction 22. Charge carrier region 28 has charge carriers of the same type of conductivity as substrate 12; it is, however, more highly doped.

Use of semiconductor component 10 according to the present invention is illustrated on the basis of the circuit arrangement shown in Figure 2, which shows an ignition power module of an ignition system of a motor vehicle. A secondary winding 32 of an ignition coil 30 is connected to a sparkplug 34 here. Primary winding 36 of ignition coil 30 is connected to a power supply voltage source formed by the automobile battery in the present application. Primary winding 36 is also connected to a switching element 38 by which primary winding 36 is connectable to the power supply voltage source. Switching element 38 is designed as a Darlington transistor stage, for example. A short-circuit switch 40 formed by bidirectional semiconductor component 10 according to the present invention is situated parallel to primary winding 36. Metallic coating 18 is connected here to switching element 38, and

metallic coating 18' is connected to the power supply voltage source.

Semiconductor component 10 in combination with the circuit configuration illustrated in Figure 2 has the following function:

A fuel-air mixture in a cylinder of an internal combustion engine may be ignited by sparkplug 34 in a known way. After the spark is extinguished, the gas mixture in the cylinder is still ionized. An ionic concentration prevailing here permits inferences regarding the combustion and knocking performance of the internal combustion engine in a known way. It is known that an accelerating voltage can be applied to the electrodes of sparkplug 34 to determine this ionic concentration, so that a resulting ionic current I forms a measure of the ionic concentration. For such a method of determining the ionic concentration, it is essential that the spark is extinguished in a defined manner after ignition of the fuel-air mixture, and ionic current I is measured immediately thereafter.

These prerequisites may be met by a low-resistance short-circuiting of primary winding 36 by semiconductor component 10 according to the present invention (switching element 40). The short circuit of primary winding 36 produces a defined extinguishing of the spark after ignition of the fuel-air mixture and minimizes the transformed serial impedance in the secondary side of the ignition circuit. This has a positive influence on the frequency response of the measurement circuit for measuring ionic current I.

To achieve defined extinguishing of the spark, a defined switching instant of semiconductor component 10 (short-circuiter 40) is required. Short-circuiter 40 is connected to power supply voltage U_{Bat} and to terminal voltage U_{CE} of switching transistor 38. The power supply voltage is approx. 14 V, while terminal voltage U_{CE} is approx. 400 V. For this voltage difference, semiconductor component 10 is to have a blocking ability of approx. 400 V. This is achieved according to the present invention by the integration of charge carrier region 28 into semiconductor component 10.

If neither poly-Si gate (electrode) 20 nor poly-Si gate (electrode) 20' is triggered, then semiconductor component 10 is blocked for both polarities. This operating state exists when primary winding 36 receives current by triggering switching transistor 38. Electrodes 18' and

20' are at the power supply voltage level in this operating state, and pn junction 22 is in blocked polarity. The doping of charge carrier regions 12 and 28 upstream from pn junction 22 is selected here so that the required blocking voltage is obtained when power supply voltage U_{Bat} is applied.

When ignition transistor 38 is switched off, it goes into bracketing, so that the spark of sparkplug 34 is ignited then in a known way. Terminal voltage U_{CE} thus amounts to approx. 400 V, so that electrodes 18 and 20 are ramped with the terminal voltage up to approx. 400 V. Semiconductor component 10 is to thus be capable of blocking this terminal voltage.

To extinguish the spark of sparkplug 34, semiconductor component 10 (short-circuiter 40) is switched by energizing electrode 20. As a result, semiconductor component 10 is first switched as a bidirectional switching element (IBGT). The voltage across the switch (i.e., between electrodes 18 and 18') is thus reduced to the static conducting-state voltage of semiconductor component 10, so that electrode 20 can also be triggered with a time lag. This changes the operating state of semiconductor component 10 to that of a MOS transistor having a finite differential resistance at the origin of its output characteristic.

Due to electrode 20' (gate for MOS transistor 26') being energized, a current flows from electrode 18' over charge carrier region 16' and into substrate 12 (drain region), so that charge carrier region 14 responds as an emitter and initiates minority charge carriers into substrate 12. This increases its conductivity. This results in a reduction in the voltage drop across semiconductor component 10, so that electrode 20 can then be energized as a gate of MOS transistor 26. This suppresses the emitter effect of charge carrier region 14, because a parallel current path is created from substrate 12 (drain) over charge carrier region 14 to charge carrier region 16. This results in tilting of the operating state of semiconductor component 10 from a bidirectional component (IGBT) to the operating state of a MOS transistor having sufficient conductivity.

Electrode 20 may either be triggered simultaneously with triggering of electrode 20' with an intermediate capacitance, or electrode 20 is triggered directly with a time offset from the triggering of electrode 20'. Either case results in triggering of the gate terminal of MOS transistor 26 after terminal voltage U_{CE} has already been reduced. All in all, this permits a

defined switching of semiconductor component 10 as short-circuiter 40 due to defined triggering of electrode 20' and electrode 20, resulting in a defined extinguishing of the spark of sparkplug 34.

Figure 3 shows a preferred embodiment of semiconductor component 10, the same parts as in Figure 1 being provided with the same reference numbers and not explained again.

As Figure 3 shows, substrate 12 is situated on a layer 42 having a doping opposite that of substrate 12 (i.e., P doping according to this example) to which ground potential 43 is connected. Layer 42 may be made of partial layers 44 and 46 having different charge carrier doping of the same type of conductivity. Due to the arrangement of layer 42, another pn junction 48 develops, its blocking voltage being determined by the doping of layer 42. Due to the stepwise doping of layers 44 and 46, the blocking voltage may be increased by using the resurf effect.

Due to the structuring of semiconductor component 10 illustrated in Figure 3, it is possible to implement a resurf technology by which the structure of semiconductor component 10 may be achieved easily.

Due to the monolithically integrated structure of semiconductor component 10, forming short-circuiter 40, it can be accommodated easily in a monolithically integrated component together with switching transistor 38. This makes it possible to eliminate the arrangement of discrete switching elements. This yields fabrication advantages for the entire ignition circuit.

The manufacture of semiconductor component 10 is illustrated schematically on the basis of Figures 4 through 6.

First, as illustrated in Figure 4, a drift layer with n-type doping is implanted in a starting wafer 50 having a p-type doping according to the doping of subsequent layer 42. This drift layer 52 having n-type doping corresponds to subsequent substrate 12. This processing is known as a standard smart power process.

Then as illustrated in Figure 5, a mask 54 having a mask opening 56 in the area of subsequent

charge carrier region 28 is situated above starting wafer 50. Then ion implantation 58 is performed with ions of n-type doping, resulting in the development of charge carrier region 28 within the substrate having n-type doping, charge carrier region 28 having a higher doping than substrate 12.

Then in method steps that are not shown in greater detail, all of them being standard method steps from the manufacture of integrated circuits, charge carrier regions 14, 14' or 16, 16' are implanted and electrodes 18, 18', 20 and 20' are applied. At the same time, other circuit components (not shown in greater detail here) are also manufactured, e.g., the control logic for triggering electrodes 20, 20', passivation layers, polysilicon layers, etc.

Abstract Of The Disclosure

A bidirectional semiconductor component having two symmetrical MOS transistor structures integrated laterally in a substrate and connected antiserially, their drain terminals being connected to one another. A zone having the same type of conductivity as the drain region yet a higher doping than that of the drain region is situated upstream from a pn junction of one of the MOS transistors in a junction area with the drain region.

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BIDIRECTIONAL SEMICONDUCTOR COMPONENT

Field Of The Invention

The present invention relates to a bidirectional semiconductor component having two symmetrical MOS transistor structures in an antiserial configuration, integrated laterally into a substrate, their drain terminals interconnected.

Background Information

Bidirectional semiconductor components of the generic type are [known. The generic semiconductor components are described by] described in S. Xu et al. in "Bidirectional LIGBT on SOI substrate with high frequency and high temperature capability" IEEE, 2/97. Due to the completely symmetrical design described there in combination with the antiserial configuration of the MOS transistors, the known bidirectional semiconductor component is suitable for use as a matrix switch in telecommunications systems or the like. Asymmetrical applications, such as those in automotive ignition system control circuits, cannot be implemented by the known bidirectional semiconductor components because the required blocking ability of approx. 400 V can be achieved only asymmetrically at the present time.

[Advantages of the] Summary Of The Invention

The bidirectional semiconductor component according to the present invention offers the advantage over the related art that it is possible to implement blocking voltages of different levels. An asymmetrical blocking ability may be achieved with a simultaneous guarantee of a low resistance at powerup due to the fact that a zone having the same type of conductivity as the drain region, however, having a higher doping than the drain region, is located upstream from a pn junction of one of the MOS transistors in a junction area with the drain region.

Due to the advantages achievable with the design of the bidirectional semiconductor

component according to the present invention, it is especially suitable for use as a short-circuit switch for short circuiting a primary winding of an ignition coil in an ignition system of a motor vehicle. It is known that with an ionic current ignition, the primary winding of the ignition coil is to be short-circuited by the secondary winding of the ignition coil after the ignition pulse has been triggered on a sparkplug because extinction of the spark is defined by this short-circuiting. In this use as provided according to the present invention, the bidirectional semiconductor component used as a short-circuit switch receives blocking voltages of different levels, namely the battery voltage on the one hand and the terminal voltage of a transistor stage connected as a Darlington, for example, on the other hand. According to the buffering of the pn junction of the one MOS transistor provided with the bidirectional semiconductor component according to the present invention, it is possible to achieve an asymmetrical blocking ability of the semiconductor component by way of which the different blocking voltages can be compensated for.

[Additional preferred embodiments of the present invention are derived from the other features mentioned in the subclaims.]

Brief Description Of The Drawings

[The present invention is illustrated in the drawing and explained in greater detail below with reference to an examplary embodiment.]

Figure 1 shows a schematic view of a bidirectional semiconductor component according to the present invention[;].

Figure 2 shows a circuit arrangement of an ignition power module using the bidirectional semiconductor component according to the present invention[;].

Figure 3 shows a preferred embodiment of the bidirectional semiconductor component according to the present invention[, and].

[Figures 4]Figures 4 and 5 show schematic process steps for manufacturing the bidirectional semiconductor component according to the present invention.

Detailed Description [of the Embodiment]

Figure 1 shows a schematic block diagram of a bidirectional semiconductor component 10. Bidirectional semiconductor component 10 includes a substrate 12 having a first charge carrier doping (e.g., n-type doping). Charge carrier regions 14 and 14' having a charge carrier doping (e.g., p-type doping) opposite the first charge carrier doping are integrated into substrate 12. Charge carrier regions 14 and 14' are symmetrical. Charge carrier regions 16 and 16' having the same charge carrier doping as substrate 12 (e.g., n-type doping) are integrated into charge carrier regions 14 and 14'. Charge carrier regions 14 and 16 are electrically connected to a common metallic coating (electrode) 18 and charge carrier regions 14' and 16' are electrically connected to a common metallic coating (electrode) 18'. Furthermore, charge carrier region 14 is provided with another insulated electrode (poly-Si gate) 20, and charge carrier region 14' is provided with another insulated electrode (poly-Si gate) 20'.

pn junctions 22 or 22' and 24 or 24' are formed due to the arrangement of charge carrier regions 12, 14, 16, and 12, 14', 16'.

Substrate 12 of the first type of conductivity is weakly doped, while charge carrier region 16 or 16' of the same type of conductivity is highly doped. Charge carrier regions 14 or 14' of the other type of conductivity is moderately doped. An antiserial configuration of two MOS transistors 26 or 26' is formed due to such an essentially known structure of semiconductor component 10.

In addition, a charge carrier region 28 extending into substrate 12 is provided for pn junction 22. Charge carrier region 28 has charge carriers of the same type of conductivity as substrate 12; it is, however, more highly doped.

Use of semiconductor component 10 according to the present invention is illustrated on the basis of the circuit arrangement shown in Figure 2, which shows an ignition power module of an ignition system of a motor vehicle. A secondary winding 32 of an ignition coil 30 is connected to a sparkplug 34 here. Primary winding 36 of ignition coil 30 is connected to a power supply voltage source formed by the automobile battery in the present application.

Primary winding 36 is also connected to a switching element 38 by which primary winding 36 is connectable to the power supply voltage source. Switching element 38 is designed as a Darlington transistor stage, for example. A short-circuit switch 40 formed by bidirectional semiconductor component 10 according to the present invention is situated parallel to primary winding 36. Metallic coating 18 is connected here to switching element 38, and metallic coating 18' is connected to the power supply voltage source.

Semiconductor component 10 in combination with the circuit configuration illustrated in Figure 2 has the following function:

A fuel-air mixture in a cylinder of an internal combustion engine may be ignited by sparkplug 34 in a known way. After the spark is extinguished, the gas mixture in the cylinder is still ionized. An ionic concentration prevailing here permits inferences regarding the combustion and knocking performance of the internal combustion engine in a known way. It is known that an accelerating voltage can be applied to the electrodes of sparkplug 34 to determine this ionic concentration, so that a resulting ionic current I forms a measure of the ionic concentration. For such a method of determining the ionic concentration, it is essential that the spark is extinguished in a defined manner after ignition of the fuel-air mixture, and ionic current I is measured immediately thereafter.

These prerequisites may be met by a low-resistance short-circuiting of primary winding 36 by semiconductor component 10 according to the present invention (switching element 40). The short circuit of primary winding 36 produces a defined extinguishing of the spark after ignition of the fuel-air mixture and minimizes the transformed serial impedance in the secondary side of the ignition circuit. This has a positive influence on the frequency response of the measurement circuit for measuring ionic current I.

To achieve defined extinguishing of the spark, a defined switching instant of semiconductor component 10 (short-circuiter 40) is required. Short-circuiter 40 is connected to power supply voltage U_{Bat} and to terminal voltage U_{CE} of switching transistor 38. The power supply voltage is approx. 14 V, while terminal voltage U_{CE} is approx. 400 V. For this voltage difference, semiconductor component 10 [must] <u>is to</u> have a blocking ability of approx. 400 V. This is achieved according to the present invention by the integration of charge carrier region 28 into

semiconductor component 10.

If neither poly-Si gate (electrode) 20 nor poly-Si gate (electrode) 20' is triggered, then semiconductor component 10 is blocked for both polarities. This operating state exists when primary winding 36 receives current by triggering switching transistor 38. Electrodes 18' and 20' are at the power supply voltage level in this operating state, and pn junction 22 is in blocked polarity. The doping of charge carrier regions 12 and 28 upstream from pn junction 22 is selected here so that the required blocking voltage is obtained when power supply voltage U_{Bat} is applied.

When ignition transistor 38 is switched off, it goes into bracketing, so that the spark of sparkplug 34 is ignited then in a known way. Terminal voltage U_{CE} thus amounts to approx. 400 V, so that electrodes 18 and 20 are ramped with the terminal voltage up to approx. 400 V. Semiconductor component 10 [must] is to thus be capable of blocking this terminal voltage.

To extinguish the spark of sparkplug 34, semiconductor component 10 (short-circuiter 40) is switched by energizing electrode 20. As a result, semiconductor component 10 is first switched as a bidirectional switching element (IBGT). The voltage across the switch (i.e., between electrodes 18 and 18') is thus reduced to the static conducting-state voltage of semiconductor component 10, so that electrode 20 can also be triggered with a time lag. This changes the operating state of semiconductor component 10 to that of a MOS transistor having a finite differential resistance at the origin of its output characteristic.

Due to electrode 20' (gate for MOS transistor [36'] 26') being energized, a current flows from electrode 18' over charge carrier region 16' and into substrate 12 (drain region), so that charge carrier region 14 responds as an emitter and initiates minority charge carriers into substrate 12. This increases its conductivity. This results in a reduction in the voltage drop across semiconductor component 10, so that electrode 20 can then be energized as a gate of MOS transistor 26. This suppresses the emitter effect of charge carrier region 14, because a parallel current path is created from substrate 12 (drain) over charge carrier region 14 to charge carrier region 16. This results in tilting of the operating state of semiconductor component 10 from a bidirectional component (IGBT) to the operating state of a MOS transistor having sufficient conductivity.

Electrode 20 may either be triggered simultaneously with triggering of electrode 20' with an intermediate capacitance, or electrode 20 is triggered directly with a time offset from the triggering of electrode 20'. Either case results in triggering of the gate terminal of MOS transistor 26 after terminal voltage U_{CE} has already been reduced. All in all, this permits a defined switching of semiconductor component 10 as short-circuiter 40 due to defined triggering of electrode 20' and electrode 20, resulting in a defined extinguishing of the spark of sparkplug 34.

Figure 3 shows a preferred embodiment of semiconductor component 10, the same parts as in Figure 1 being provided with the same reference numbers and not explained again.

As Figure 3 shows, substrate 12 is situated on a layer 42 having a doping opposite that of substrate 12 (i.e., P doping according to this example) to which ground potential 43 is connected. Layer 42 may be made of partial layers 44 and 46 having different charge carrier doping of the same type of conductivity. Due to the arrangement of layer 42, another pn junction 48 develops, its blocking voltage being determined by the doping of layer 42. Due to the stepwise doping of layers 44 and 46, the blocking voltage may be increased by using the resurf effect.

Due to the structuring of semiconductor component 10 illustrated in Figure 3, it is possible to implement a resurf technology by which the structure of semiconductor component 10 may be achieved easily.

Due to the monolithically integrated structure of semiconductor component 10, forming short-circuiter 40, it can be accommodated easily in a monolithically integrated component together with switching transistor 38. This makes it possible to eliminate the arrangement of discrete switching elements. This yields [essential] fabrication advantages for the entire ignition circuit.

The manufacture of semiconductor component 10 is illustrated schematically on the basis of Figures 4 through 6.

First, as illustrated in Figure 4, a drift layer with n-type doping is implanted in a starting

wafer 50 having a p-type doping according to the doping of subsequent layer 42. This drift layer 52 having n-type doping corresponds to subsequent substrate 12. This processing is known as a standard smart power process.

Then as illustrated in Figure 5, a mask 54 having a mask opening 56 in the area of subsequent charge carrier region 28 is situated above starting wafer 50. Then ion implantation 58 is performed with ions of n-type doping, resulting in the development of charge carrier region 28 within the substrate having n-type doping, charge carrier region 28 having a higher doping than substrate 12.

Then in method steps that are not shown in greater detail, all of them being standard method steps from the manufacture of integrated circuits, charge carrier regions 14, 14' or 16, 16' are implanted and electrodes 18, 18', 20 and 20' are applied. At the same time, other circuit components (not shown in greater detail here) are also manufactured, e.g., the control logic for triggering electrodes 20, 20', passivation layers, polysilicon layers, etc.

Abstract Of The Disclosure

A bidirectional semiconductor component [has] having two symmetrical MOS transistor structures integrated laterally in a substrate and connected antiserially, their drain terminals being connected to one another. [ ]A zone [(28)] having the same type of conductivity as the drain region yet a higher doping than that of the drain region [(12)] is situated upstream from a pn junction [(22)] of one of the MOS transistors [(26)] in a junction area with the drain region[(12)].

[(Figure 1)]

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531 Rec'd PCT/PTO 17 JAN 2002

[10191/2231]

BIDIRECTIONAL SEMICONDUCTOR COMPONENT

The present invention relates to a bidirectional semiconductor component having two symmetrical MOS transistor structures in an antiserial configuration, integrated laterally into a substrate, their drain terminals interconnected.

Background Information

Bidirectional semiconductor components of the generic type are known. The generic semiconductor components are described by S. Xu et al. in "Bidirectional LIGBT on SOI substrate with high frequency and high temperature capability" IEEE, 2/97. Due to the completely symmetrical design described there in combination with the antiserial configuration of the MOS transistors, the known bidirectional semiconductor component is suitable for use as a matrix switch in telecommunications systems or the like. Asymmetrical applications, such as those in automotive ignition system control circuits, cannot be implemented by the known bidirectional semiconductor components because the required blocking ability of approx. 400 V can be achieved only asymmetrically at the present time.

Advantages of the Invention

The bidirectional semiconductor component according to the present invention offers the advantage over the related art that it is possible to implement blocking voltages of different levels. An asymmetrical blocking ability may be achieved with a simultaneous guarantee of a low resistance at powerup due to the fact that a zone having the same type of conductivity as the drain region, however, having a higher doping than the drain region, is located upstream from a pn junction of one of the MOS transistors in a junction area with the drain region.

Due to the advantages achievable with the design of the bidirectional semiconductor component according to the present invention, it is especially suitable for use as a short-

circuit switch for short circuiting a primary winding of an ignition coil in an ignition system of a motor vehicle. It is known that with an ionic current ignition, the primary winding of the ignition coil is to be short-circuited by the secondary winding of the ignition coil after the ignition pulse has been triggered on a sparkplug because extinction of the spark is defined by this short-circuiting. In this use as provided according to the present invention, the bidirectional semiconductor component used as a short-circuit switch receives blocking voltages of different levels, namely the battery voltage on the one hand and the terminal voltage of a transistor stage connected as a Darlington, for example, on the other hand. According to the buffering of the pn junction of the one MOS transistor provided with the bidirectional semiconductor component according to the present invention, it is possible to achieve an asymmetrical blocking ability of the semiconductor component by way of which the different blocking voltages can be compensated for.

Additional preferred embodiments of the present invention are derived from the other features mentioned in the subclaims.

Drawings

The present invention is illustrated in the drawing and explained in greater detail below with reference to an examplary embodiment.

Figure 1 shows a schematic view of a bidirectional semiconductor component according to the present invention;

Figure 2 shows a circuit arrangement of an ignition power module using the bidirectional semiconductor component according to the present invention;

Figure 3 shows a preferred embodiment of the bidirectional semiconductor component according to the present invention, and

Figures 4 and 5 show schematic process steps for manufacturing the bidirectional semiconductor component according to the present invention.

Description of the Embodiment

Figure 1 shows a schematic block diagram of a bidirectional semiconductor component 10. Bidirectional semiconductor component 10 includes a substrate 12 having a first charge carrier doping (e.g., n-type doping). Charge carrier regions 14 and 14' having a charge carrier doping (e.g., p-type doping) opposite the first charge carrier doping are integrated into substrate 12. Charge carrier regions 14 and 14' are symmetrical. Charge carrier regions 16 and 16' having the same charge carrier doping as substrate 12 (e.g., n-type doping) are integrated into charge carrier regions 14 and 14'. Charge carrier regions 14 and 16 are electrically connected to a common metallic coating (electrode) 18 and charge carrier regions 14' and 16' are electrically connected to a common metallic coating (electrode) 18'. Furthermore, charge carrier region 14 is provided with another insulated electrode (poly-Si gate) 20, and charge carrier region 14' is provided with another insulated electrode (poly-Si gate) 20'.

pn junctions 22 or 22' and 24 or 24' are formed due to the arrangement of charge carrier regions 12, 14, 16, and 12, 14', 16'.

Substrate 12 of the first type of conductivity is weakly doped, while charge carrier region 16 or 16' of the same type of conductivity is highly doped. Charge carrier regions 14 or 14' of the other type of conductivity is moderately doped. An antiserial configuration of two MOS transistors 26 or 26' is formed due to such an essentially known structure of semiconductor component 10.

In addition, a charge carrier region 28 extending into substrate 12 is provided for pn junction 22. Charge carrier region 28 has charge carriers of the same type of conductivity as substrate 12; it is, however, more highly doped.

Use of semiconductor component 10 according to the present invention is illustrated on the basis of the circuit arrangement shown in Figure 2, which shows an ignition power module of an ignition system of a motor vehicle. A secondary winding 32 of an ignition coil 30 is connected to a sparkplug 34 here. Primary winding 36 of ignition coil 30 is connected to a power supply voltage source formed by the automobile battery in the present application.

Primary winding 36 is also connected to a switching element 38 by which primary winding 36 is connectable to the power supply voltage source. Switching element 38 is designed as a Darlington transistor stage, for example. A short-circuit switch 40 formed by bidirectional semiconductor component 10 according to the present invention is situated parallel to primary winding 36. Metallic coating 18 is connected here to switching element 38, and metallic coating 18' is connected to the power supply voltage source.

Semiconductor component 10 in combination with the circuit configuration illustrated in Figure 2 has the following function:

A fuel-air mixture in a cylinder of an internal combustion engine may be ignited by sparkplug 34 in a known way. After the spark is extinguished, the gas mixture in the cylinder is still ionized. An ionic concentration prevailing here permits inferences regarding the combustion and knocking performance of the internal combustion engine in a known way. It is known that an accelerating voltage can be applied to the electrodes of sparkplug 34 to determine this ionic concentration, so that a resulting ionic current I forms a measure of the ionic concentration. For such a method of determining the ionic concentration, it is essential that the spark is extinguished in a defined manner after ignition of the fuel-air mixture, and ionic current I is measured immediately thereafter.

These prerequisites may be met by a low-resistance short-circuiting of primary winding 36 by semiconductor component 10 according to the present invention (switching element 40). The short circuit of primary winding 36 produces a defined extinguishing of the spark after ignition of the fuel-air mixture and minimizes the transformed serial impedance in the secondary side of the ignition circuit. This has a positive influence on the frequency response of the measurement circuit for measuring ionic current I.

To achieve defined extinguishing of the spark, a defined switching instant of semiconductor component 10 (short-circuiter 40) is required. Short-circuiter 40 is connected to power supply voltage U_{Bat} and to terminal voltage U_{CE} of switching transistor 38. The power supply voltage is approx. 14 V, while terminal voltage U_{CE} is approx. 400 V. For this voltage difference, semiconductor component 10 must have a blocking ability of approx. 400 V. This is achieved according to the present invention by the integration of charge carrier region 28 into

semiconductor component 10.

If neither poly-Si gate (electrode) 20 nor poly-Si gate (electrode) 20' is triggered, then semiconductor component 10 is blocked for both polarities. This operating state exists when primary winding 36 receives current by triggering switching transistor 38. Electrodes 18' and 20' are at the power supply voltage level in this operating state, and pn junction 22 is in blocked polarity. The doping of charge carrier regions 12 and 28 upstream from pn junction 22 is selected here so that the required blocking voltage is obtained when power supply voltage U_{Bat} is applied.

When ignition transistor 38 is switched off, it goes into bracketing, so that the spark of sparkplug 34 is ignited then in a known way. Terminal voltage U_{CE} thus amounts to approx. 400 V, so that electrodes 18 and 20 are ramped with the terminal voltage up to approx. 400 V. Semiconductor component 10 must thus be capable of blocking this terminal voltage.

To extinguish the spark of sparkplug 34, semiconductor component 10 (short-circuiter 40) is switched by energizing electrode 20. As a result, semiconductor component 10 is first switched as a bidirectional switching element (IBGT). The voltage across the switch (i.e., between electrodes 18 and 18') is thus reduced to the static conducting-state voltage of semiconductor component 10, so that electrode 20 can also be triggered with a time lag. This changes the operating state of semiconductor component 10 to that of a MOS transistor having a finite differential resistance at the origin of its output characteristic.

Due to electrode 20' (gate for MOS transistor 36') being energized, a current flows from electrode 18' over charge carrier region 16' and into substrate 12 (drain region), so that charge carrier region 14 responds as an emitter and initiates minority charge carriers into substrate 12. This increases its conductivity. This results in a reduction in the voltage drop across semiconductor component 10, so that electrode 20 can then be energized as a gate of MOS transistor 26. This suppresses the emitter effect of charge carrier region 14, because a parallel current path is created from substrate 12 (drain) over charge carrier region 14 to charge carrier region 16. This results in tilting of the operating state of semiconductor component 10 from a bidirectional component (IGBT) to the operating state of a MOS transistor having sufficient conductivity.

Electrode 20 may either be triggered simultaneously with triggering of electrode 20' with an intermediate capacitance, or electrode 20 is triggered directly with a time offset from the triggering of electrode 20'. Either case results in triggering of the gate terminal of MOS transistor 26 after terminal voltage U_{CE} has already been reduced. All in all, this permits a defined switching of semiconductor component 10 as short-circuiter 40 due to defined triggering of electrode 20' and electrode 20, resulting in a defined extinguishing of the spark of sparkplug 34.

Figure 3 shows a preferred embodiment of semiconductor component 10, the same parts as in Figure 1 being provided with the same reference numbers and not explained again.

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Due to the structuring of semiconductor component 10 illustrated in Figure 3, it is possible to implement a resurf technology by which the structure of semiconductor component 10 may be achieved easily.

Due to the monolithically integrated structure of semiconductor component 10, forming short-circuiter 40, it can be accommodated easily in a monolithically integrated component together with switching transistor 38. This makes it possible to eliminate the arrangement of discrete switching elements. This yields essential fabrication advantages for the entire ignition circuit.

The manufacture of semiconductor component 10 is illustrated schematically on the basis of Figures 4 through 6.

First, as illustrated in Figure 4, a drift layer with n-type doping is implanted in a starting

wafer 50 having a p-type doping according to the doping of subsequent layer 42. This drift layer 52 having n-type doping corresponds to subsequent substrate 12. This processing is known as a standard smart power process.

Then as illustrated in Figure 5, a mask 54 having a mask opening 56 in the area of subsequent charge carrier region 28 is situated above starting wafer 50. Then ion implantation 58 is performed with ions of n-type doping, resulting in the development of charge carrier region 28 within the substrate having n-type doping, charge carrier region 28 having a higher doping than substrate 12.

Then in method steps that are not shown in greater detail, all of them being standard method steps from the manufacture of integrated circuits, charge carrier regions 14, 14' or 16, 16' are implanted and electrodes 18, 18', 20 and 20' are applied. At the same time, other circuit components (not shown in greater detail here) are also manufactured, e.g., the control logic for triggering electrodes 20, 20', passivation layers, polysilicon layers, etc.

What is claimed is:

1. A bidirectional semiconductor component having two symmetrical MOS transistor structures integrated laterally in a substrate and connected antiserially, their drain terminals being connected to one another,
wherein a zone (28) having the same type of conductivity as the drain region yet a higher doping than that of the drain region (12) is situated upstream from a pn junction (22) of one of the MOS transistors (26) in a junction area with the drain region (12).

2. The bidirectional semiconductor component according to Claim 1,
wherein the drain region (12) and the zone (28) are n-doped.

3. The bidirectional semiconductor component according to one of the preceding claims,
wherein the drain region (12) is situated on a layer (42) having a doping of the opposite type of conductivity from the drain region (12).

4. The bidirectional semiconductor component according to Claim 3,
wherein the layer (42) is made up of partial layers (44, 46) having stepped doping.

5. A use of a bidirectional semiconductor component according to one of Claims 1 through 4 as short-circuit switch (40) for short circuiting a primary winding (36) of an ignition coil (30) in an ignition power module of an ignition system of an internal combustion engine.

6. The use according to Claim 5,
characterized by a time-staggered activation of the gate terminals (20, 20') of the MOS transistor structures (26, 26'), the MOS transistor (26), which blocks a higher voltage (U_{CE}), being activated later.

7. The use according to Claim 6,
wherein the time-staggered activation is accomplished by interconnecting a capacitor (bootstrap).

8. The use according to Claim 6,

wherein the time-staggered activation is accomplished by a time control.

Abstract

A bidirectional semiconductor component has two symmetrical MOS transistor structures integrated laterally in a substrate and connected antiserially, their drain terminals being connected to one another.

A zone (28) having the same type of conductivity as the drain region yet a higher doping than that of the drain region (12) is situated upstream from a pn junction (22) of one of the MOS transistors (26) in a junction area with the drain region (12).

(Figure 1)

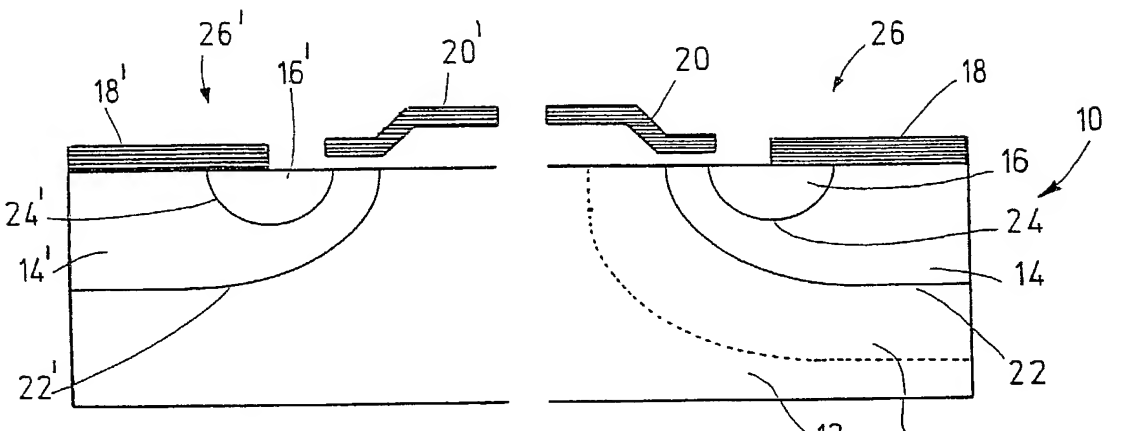

Fig.1

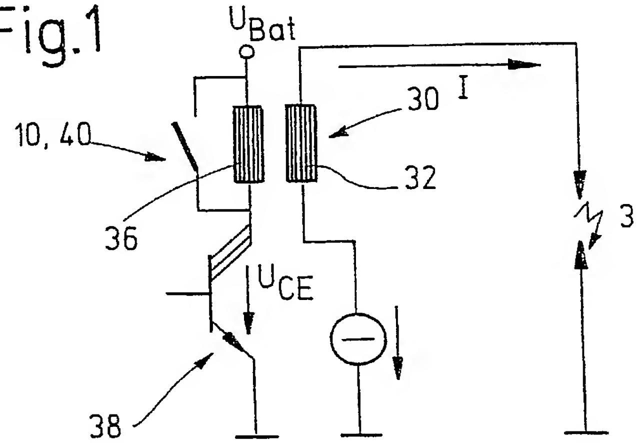

Fig.2

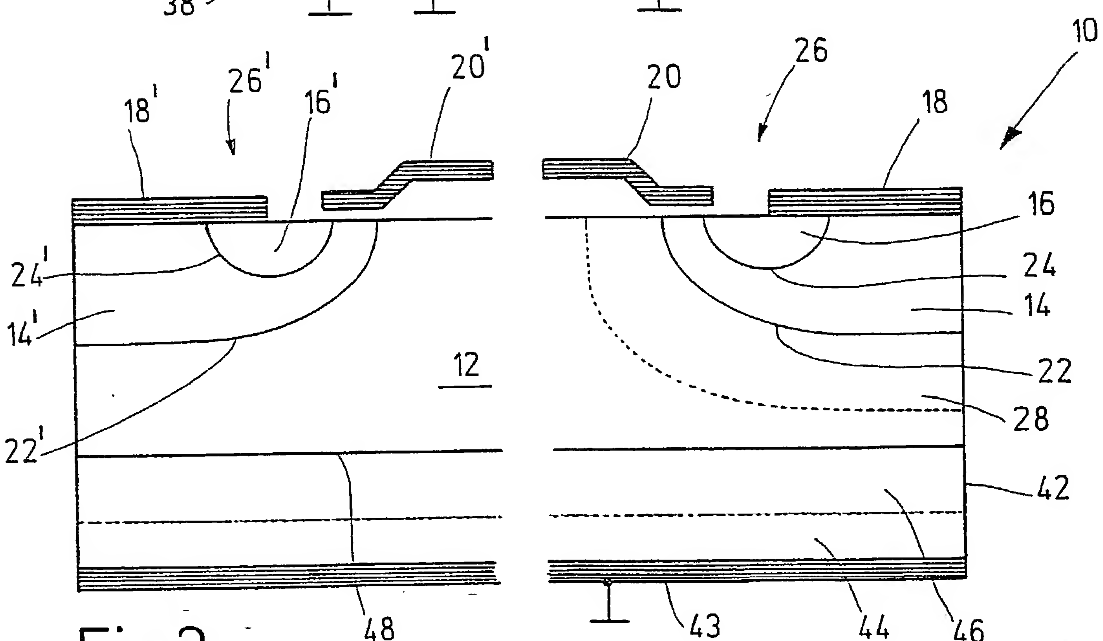

Fig.3

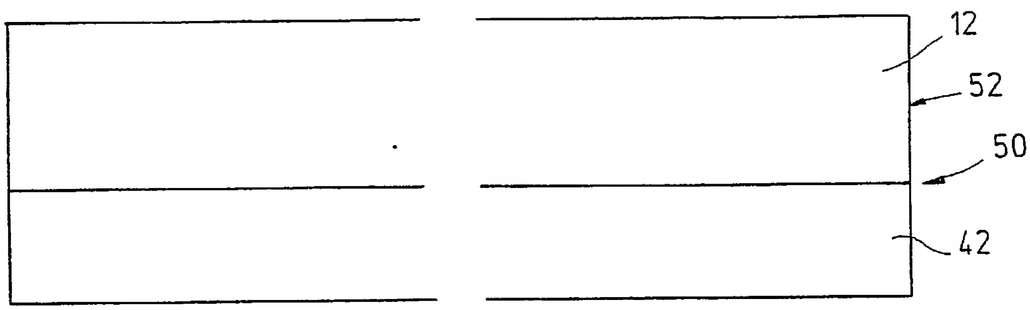

Fig.4

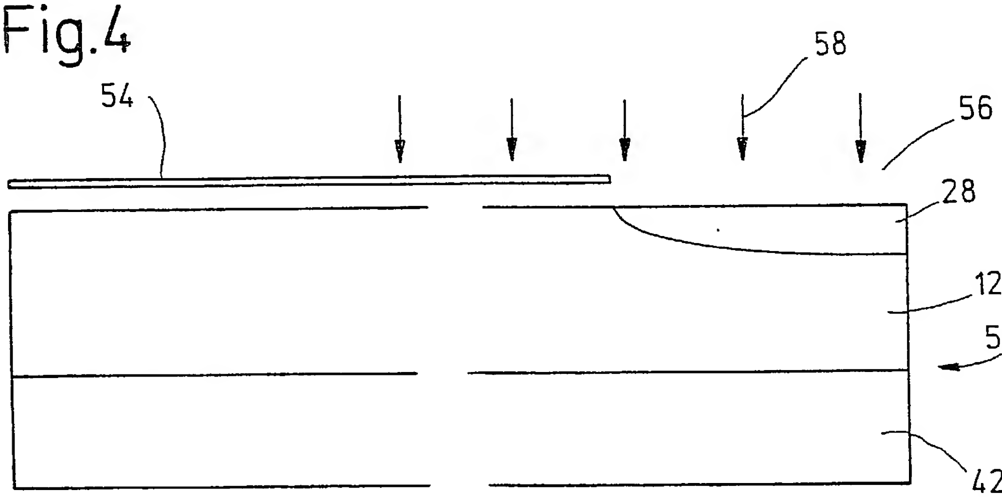

Fig.5

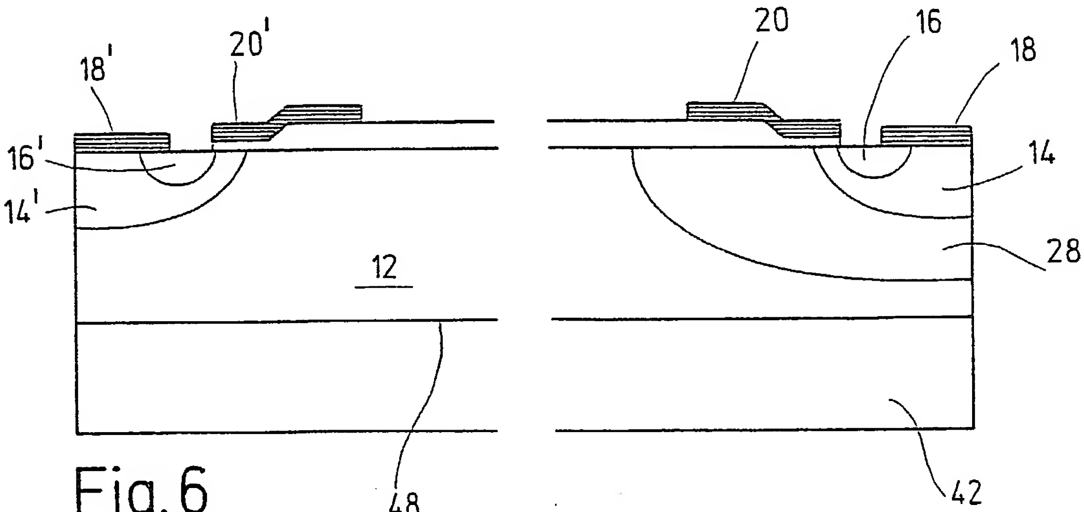

Fig.6

[10191/2231]

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **BIDIRECTIONAL SEMICONDUCTOR COMPONENT**, the specification of which was filed as International Application No. PCT/DE00/02061 on June 24, 2000.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

EV003626160US

PRIOR FOREIGN APPLICATION(S)

Number	Country Filed	Day/Month/Year	Priority Claimed Under 35 USC 119
199 33 969.4	Fed. Rep. of Germany	20 July 1999	Yes

And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Please address all communications regarding this application to:

KENYON & KENYON
One Broadway
New York, New York 10004

Customer No. 26646

Please direct all telephone calls to Richard L. Mayer at (212) 425-7200.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

1-00 Inventor: **Robert PLIKAT**

Inventor's Signature: Robert Plikat

Date: 02/11/2002

Residence: ~~Leinsbachstr. 8~~ Maronenweg 14
~~72800 Eningen~~ 71665 Vaihingen/Enz DEX
Federal Republic of Germany

Citizenship: Federal Republic of Germany

Post Office Address: Same as above.

2-00 Inventor: **Wolfgang FEILER**

Inventor's Signature: Dr. Wolfgang Feiler

Date: 08.02.2002

Residence: Hundsschleestr. 7/1
72766 Reutlingen DEX
Federal Republic of Germany

Citizenship: Federal Republic of Germany

Post Office Address: Same as above.